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National Field Investigations Center-Cincinnati, Ohio

1970

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BIOLOGICAL SURVEY OF HARLAN COUNTY RESERVOIR - NEBRASKA

August 1969

Nelson A. Thomas and Allen M. Lucas

National Field Investigations Center
Federal Water Quality Administration
United States Department of the Interior
Cincinnati, Ohio

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SUMMARY

1. Investigations conducted August 8-9, 1969, on Harlan County Reservoir, Nebraska, and the Republican River indicated excellent water quality both upstream and downstream from the reservoir.

2. In the reservoir, sufficient phosphorus was present for the development of an algal population much larger than existed. Inorganic nitrogen probably limited the development of the algal population.

3. The phytoplankton population downstream from the reservoir totaled only 3 percent of the algal population found upstream.

4. The reservoir contained sufficient algae that supported an abundant population of bottom animals capable of maintaining an excellent fish population. This algal population was not large enough to create problems, such as fluctuating dissolved oxygen concentrations, high pH, and shoreline wind rows of dead algae.

5. The population of bottom animals, both upstream and downstream from the reservoir, reflected high water quality. The population and diversity of bottom animals downstream indicated

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that the reservoir improved water quality by the removal of silt.

6. Low D. C. concentrations of 1 mg/l in the deepest section of the impoundment limited the population of bottom animals to a few pollution tolerant sludgeworms.

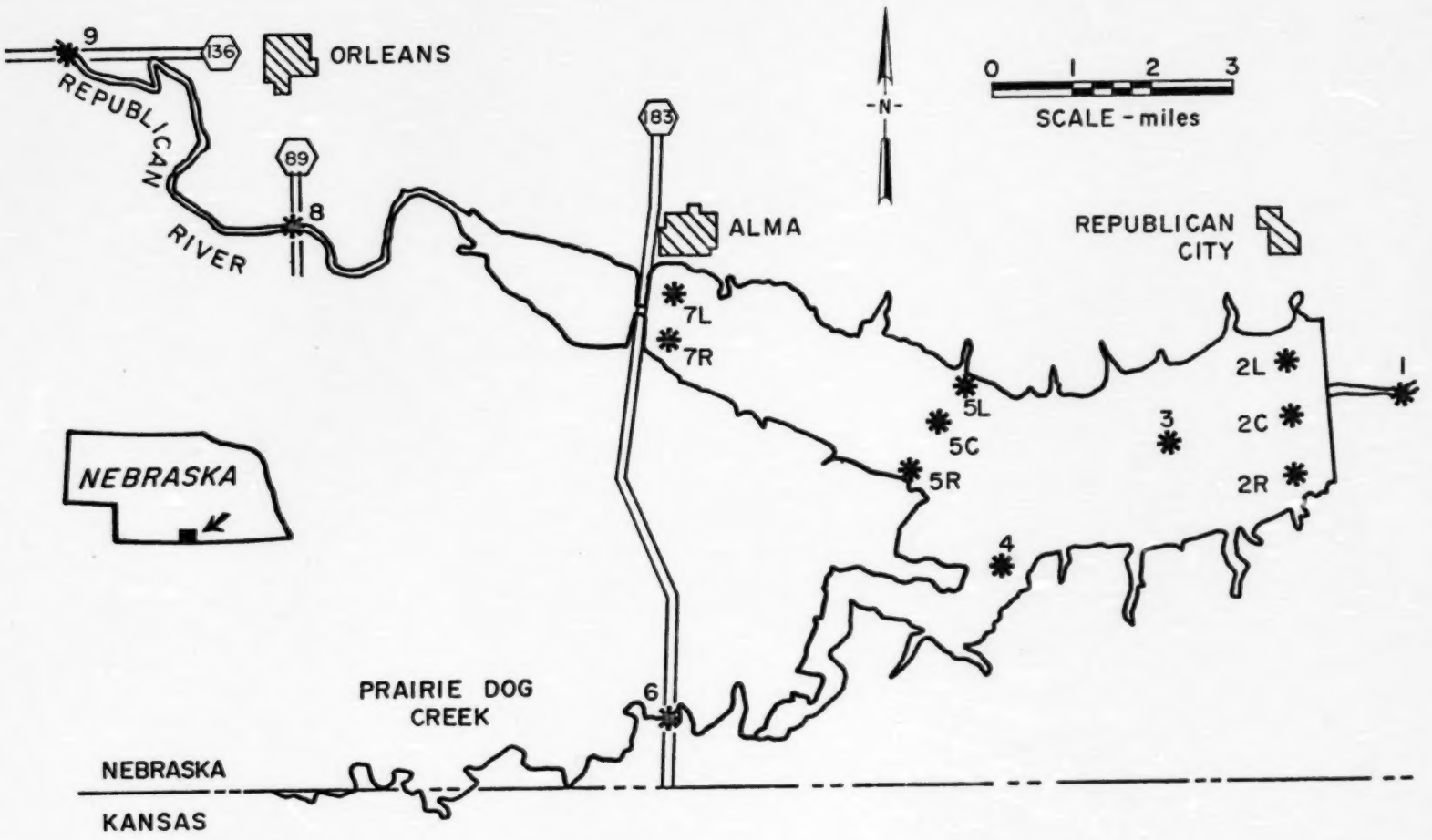

FIGURE 1. SAMPLING STATIONS, HARLAN COUNTY RESERVOIR, NEBRASKA, 1969.

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BIOLOGICAL SURVEY OF

HARLAN COUNTY RESERVOIR, NEBRASKA

August 1969

At the request of the Army Corps of Engineers, through the Regional Director, Missouri Basin Region, Federal Water Quality Administration (FWQA), a biological study was conducted on the Republican River and Harlan County Reservoir on August 8-9, 1969. The investigation was to determine the water quality of the reservoir and the Republican River as indicated by the aquatic biota, and consisted of samples from two upstream stations, four mainstem reservoir stations, two tributary stations, and one station downstream from the reservoir (Figure 1). Biologists from the FWQA's National Field Investigations Center sampled the phytoplankton and bottom animal communities, and determined primary production, light penetration, and algal nutrients. Personnel from the State of Nebraska, Department of Health, sampled the reservoir and the Republican River and determined physical and chemical water quality characteristics. Some of the data used in this report will be presented in the comprehensive report.

Algal nutrient samples were analyzed according to the FWQA Methods for Chemical Analysis of Water and Wastes (1969). Plankton

productivity was determined by dissolved oxygen (DO) differences with the light and dark bottle technique.

RESERVOIR DESCRIPTION

Harlan County Reservoir was completed in 1953. The 11,850 foot long dam across the Republican River Valley controls drainage from a 20,755 square mile area of south central Nebraska. The principal use of the reservoir is for flood control; however, downstream from the reservoir thousands of acres are irrigated from this project. The reservoir, popular for fishing and boating activities, has a total capacity of 850,000 acre feet of which 500,000 acre feet are for flood control and 350,000 acre feet are for irrigation, recreation, water supply, and the maintenance of downstream water quality during periods of low flow.

PHYSICAL AND CHEMICAL

The concentration of total suspended solids was the highest in the flowage area (station 7) and caused increased turbidity. During the survey, high winds were prevalent which probably resuspended previously deposited silt. Total suspended solids decreased from 506 mg/l at station 7 to 66 mg/l at station 5 (Figure 2). This decrease in total suspended solids was reflected in the decrease in turbidity, 416 to 41 Jackson Turbidity Units (JTU) from station 7 to station 5, and resulted in an increased depth of the euphotic zone from 15 inches at station 7, to 8 feet at station 5. The euphotic zone reached a maximum depth of 10 feet at station 2, where the lowest turbidity (11 JTU) occurred also.

As a result of the settling of materials in the reservoir, the downstream water quality was improved. Total suspended solids decreased from 278 mg/l upstream from the reservoir (station 9) to 26 mg/l downstream (station 1). Similarly, the turbidity decreased from 181 JTU upstream from the reservoir (station 9) to 18 JTU downstream from the dam (station 1).

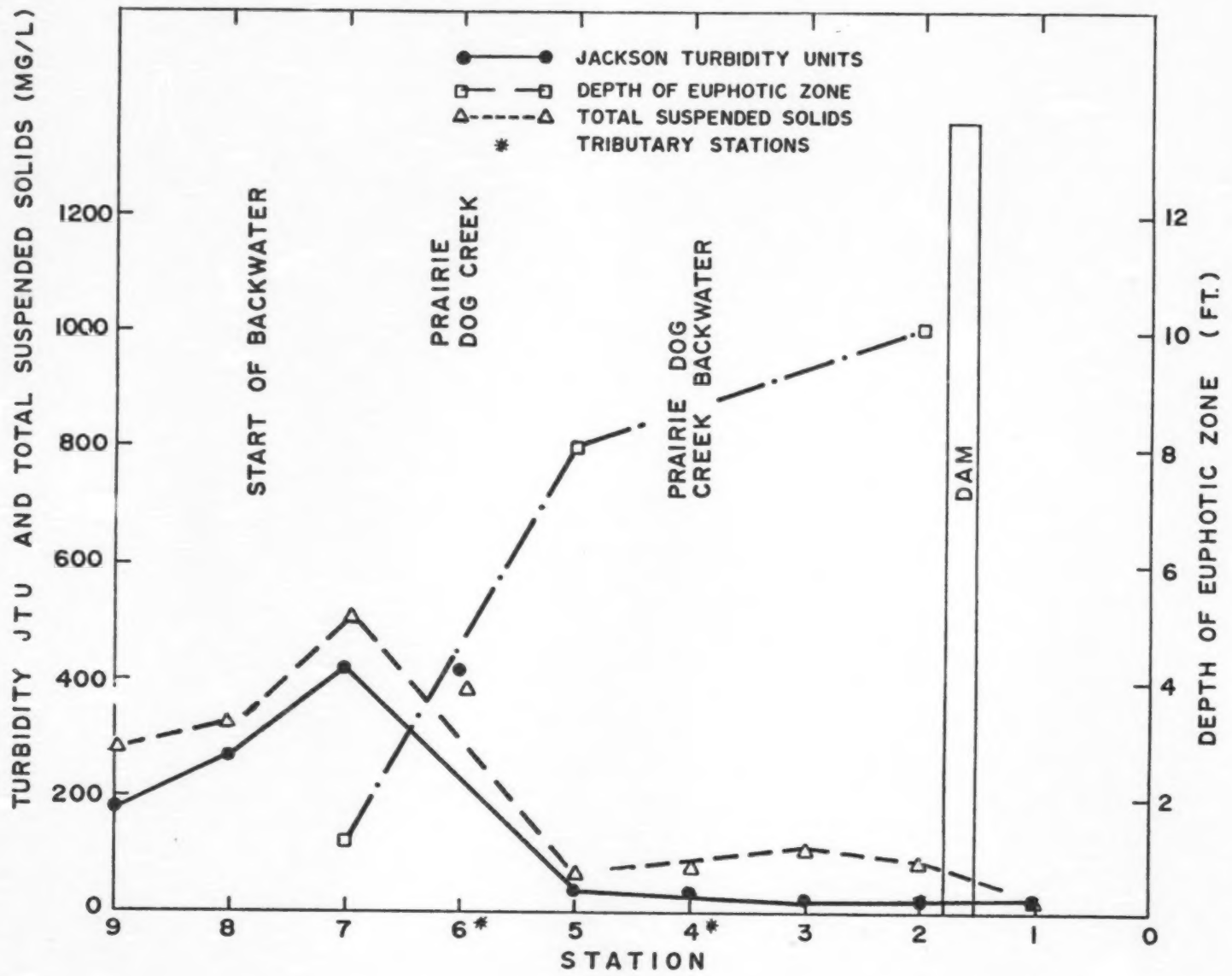

Fig. 2 Turbidity, Total Suspended Solids, and Depth of Euphotic Zone, Harlan County Reservoir, Nebraska, 1969

Harlan County Reservoir did not have a definable thermocline: however, thermal stratification apparently was sufficient to prevent complete mixing. In the deepest portion of the reservoir, the water was stratified at a depth approximately 40 feet (Figure 3) with a surface temperature of 25.5° and a bottom temperature of 23.5° (station 2). The incomplete mixing resulted in a decrease in dissolved oxygen (DO) from 7.2 mg/l at the surface to 1.0 mg/l at the bottom (55 feet). Decomposition of detrital material that settled from the more productive upper layers of the reservoir caused the low DO concentrations.

The Republican River, upstream from the reservoir, contained sufficient soluble phosphorus (0.17 mg/l) to promote algal growth. The concentration of 0.4 mg/l total phosphorus was eight times higher than the .05 mg/l suggested by Mackenthun (1968)[1] as the critical level in the influent water which will result in nuisance growths in a reservoir.

Because other algal growth factors were favorable, inorganic nitrogen was probably the limiting algal nutrient in the river upstream from the reservoir. The concentration in this reach was less than 0.2 mg/l. The ratio of inorganic nitrogen

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[1] Mackenthun, K. M. 1968. The Phosphorus Problem. Jour. Am. Water Works Assoc., 60 (9): 1047-1054.

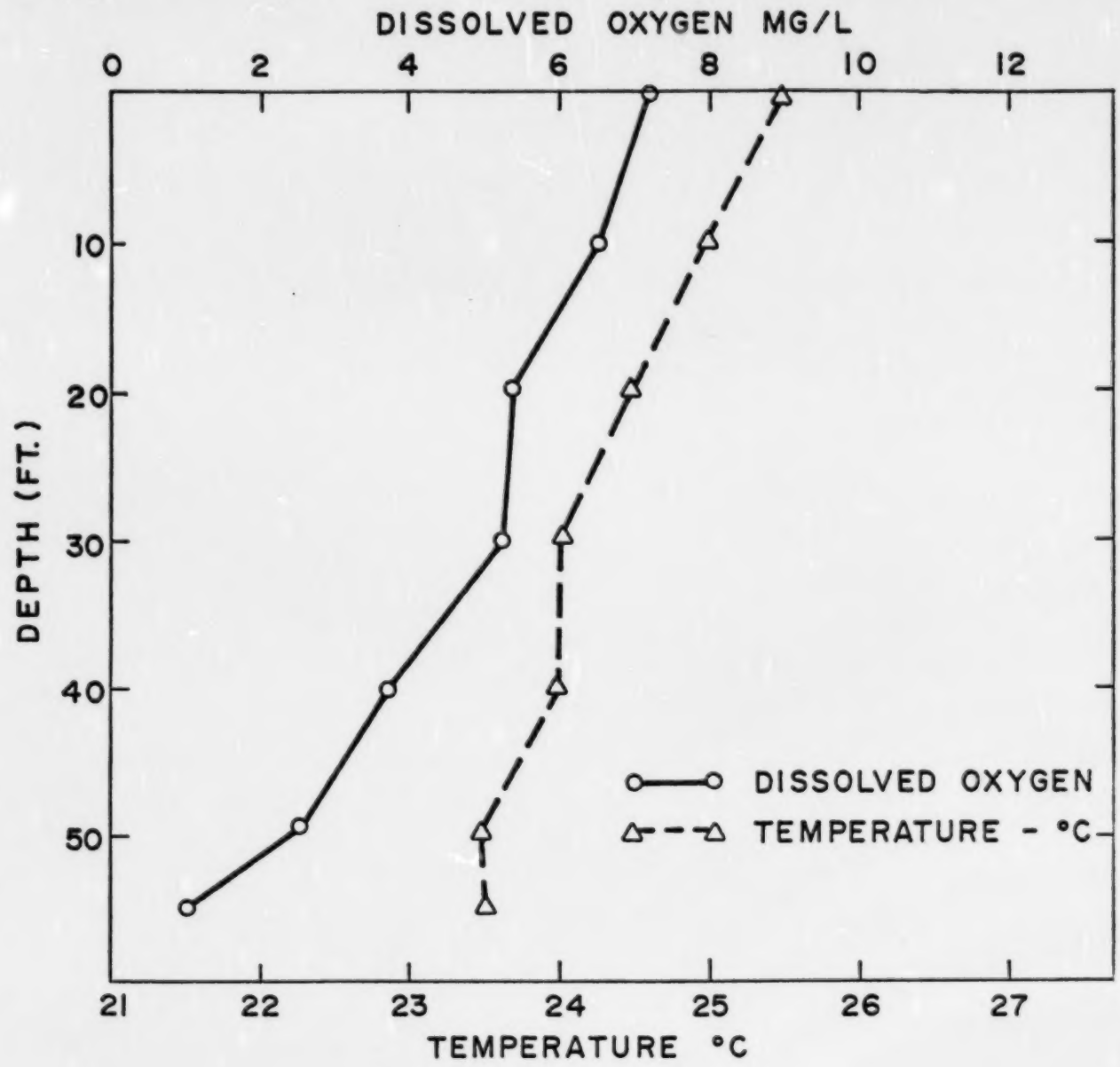

Fig. 3 Dissolved Oxygen and Temperature Profiles at Station 2. Harlan County Reservoir, Nebraska, 1969.

to soluble phosphorus was 1. A ratio of less than 7 favors the development of blue-green algae because they have the ability to fix inorganic nitrogen from the atmospheric nitrogen dissolved in the water.

The concentration of soluble phosphorus remained high (0.04 mg/l) throughout the reservoir. Phosphorus did not limit algal productivity in the reservoir. The concentration of inorganic nitrogen remained quite low (approximately 0.2 mg/l) throughout the reservoir. Some samples from the upper 10 feet contained significant concentrations of ammonia (0.3 - 0.4 mg/l): however, there was not a significant increase in the phytoplankton population.

PHYTOPLANKTON

The Republican River upstream from Harlan County Reservoir supported a large algal population (29,600 algae/ml or 70 ppm wet volume). An algal population of this number is unusual for flowing waters. The phytoplankton population was comprised of only 20 percent blue-green algae which is also unusual in the presence of a nitrogen deficiency. The algal cell volume decrease from 70 to 15 ppm from station 9 to station 7 (Figure 4) probably was the result of the adherence and subsequent settling of silt particles and algal cells. This decrease in the algal population is unusual since most reservoirs have peak production in the upstream reaches.

In the backwater reach of the reservoir (station 7), primary production for the euphotic zone was 605 $mg/m^2/day$. The surface productivity at this station was 2,100 $mg/m^3/day$ which, when considered with the volume of algae present, would categorize this reach of the reservoir as eutrophic. The low light penetration in this area limited the productivity to the surface waters.

The phytoplankton population in the main sector of the reservoir was largest in the euphotic zone, which is typical of

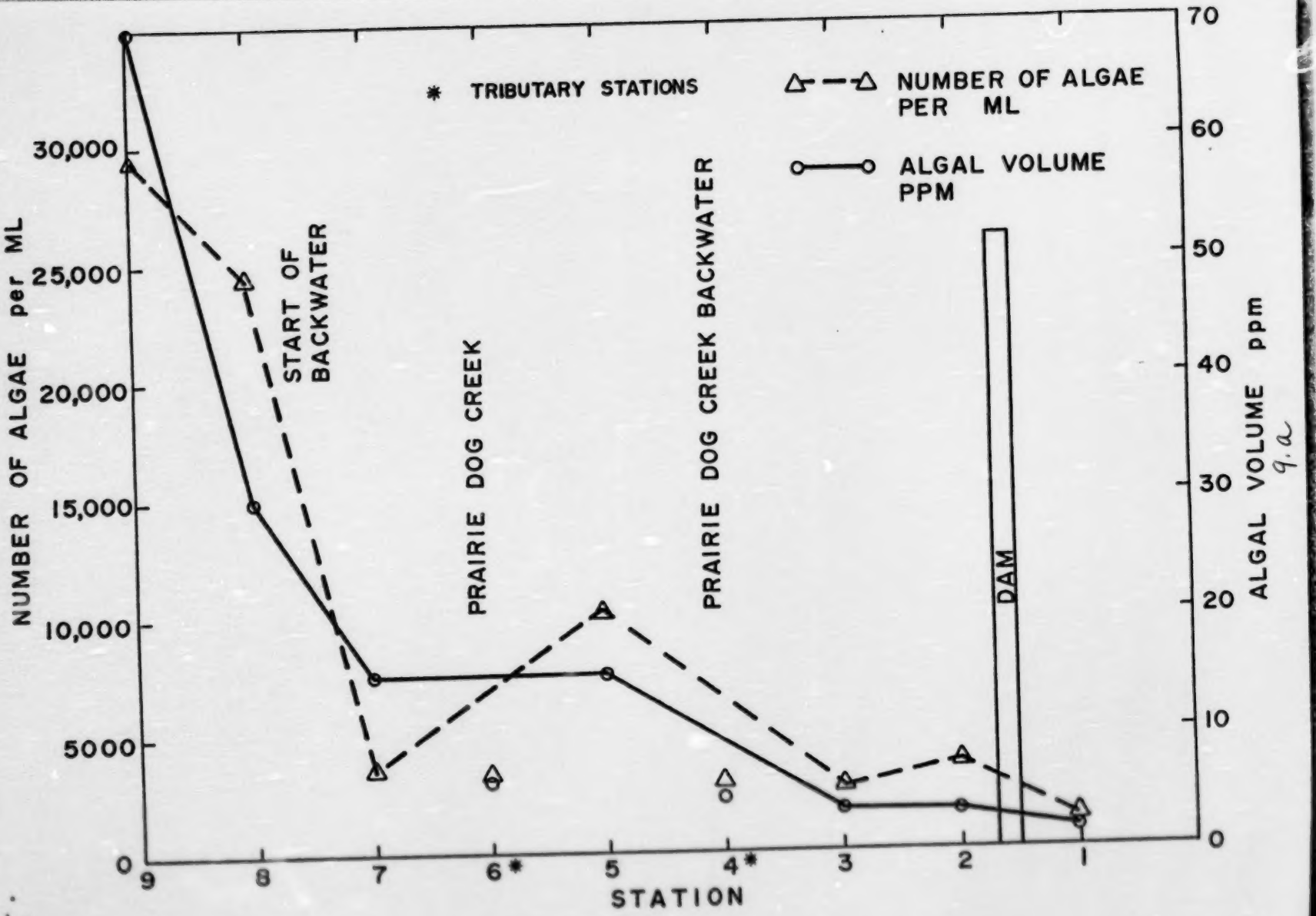

Fig. 4 Number of Algae and Algal Volumes
Harlan County Reservoir, Nebraska, 1969

9.a

most bodies of water. At station 3 there were less than 1,000 algae/ml present below the 10 foot depth. Algal volumes were smallest in the lower strata of the reservoir.

The phytoplankton population decreased downstream and near the dam there was 3,900 algae/ml or 3.6 ppm (station 2). Even though the algal community was smallest in this section of the reservoir, productivity was highest because of the deep euphotic zone (10 feet). Primary production in the euphotic zone was measured at .727 mg/m^2/day at station 2 which indicates the main portion of Harlan County Reservoir was moderately productive (mesotrophic).

Downstream from the reservoir (station 1), the percent of blue-green algae reached 40 percent (705 algae/ml). Higher concentrations of inorganic nitrogen resulted in a nitrogen to phosphorus ratio of 5.

BOTTOM ANIMALS

The community of bottom animals upstream from Harlan County Reservoir reflected excellent water quality. At station 9 the population was composed of 14 kinds of organisms at 242 per square foot (Figure 5) and contained pollution sensitive organisms such as stoneflies, mayflies and caddisflies. At station 7, a backwater area with reduced velocity and increased siltation, the bottom animal community decreased to 19 per square foot. Bottom animals numbered 27 to 143 organisms per square foot in the middle sector of the reservoir (station 5). Many of the bottom animals that inhabited the reservoir floor were midges which provide good fish food just after hatching. In the deepest part of the reservoir (station 2), the benthic population was 8 sludgeworms per square foot. This degraded benthic population reflected the low DO concentrations present in the deeper waters.

Downstream from the reservoir, after sufficient reaeration had restored the DO to 8.5 mg/l, benthic communities typical of a flowing river developed. At station 1, the bottom animals numbered 760 per square foot and had a diversity of 17 kinds.

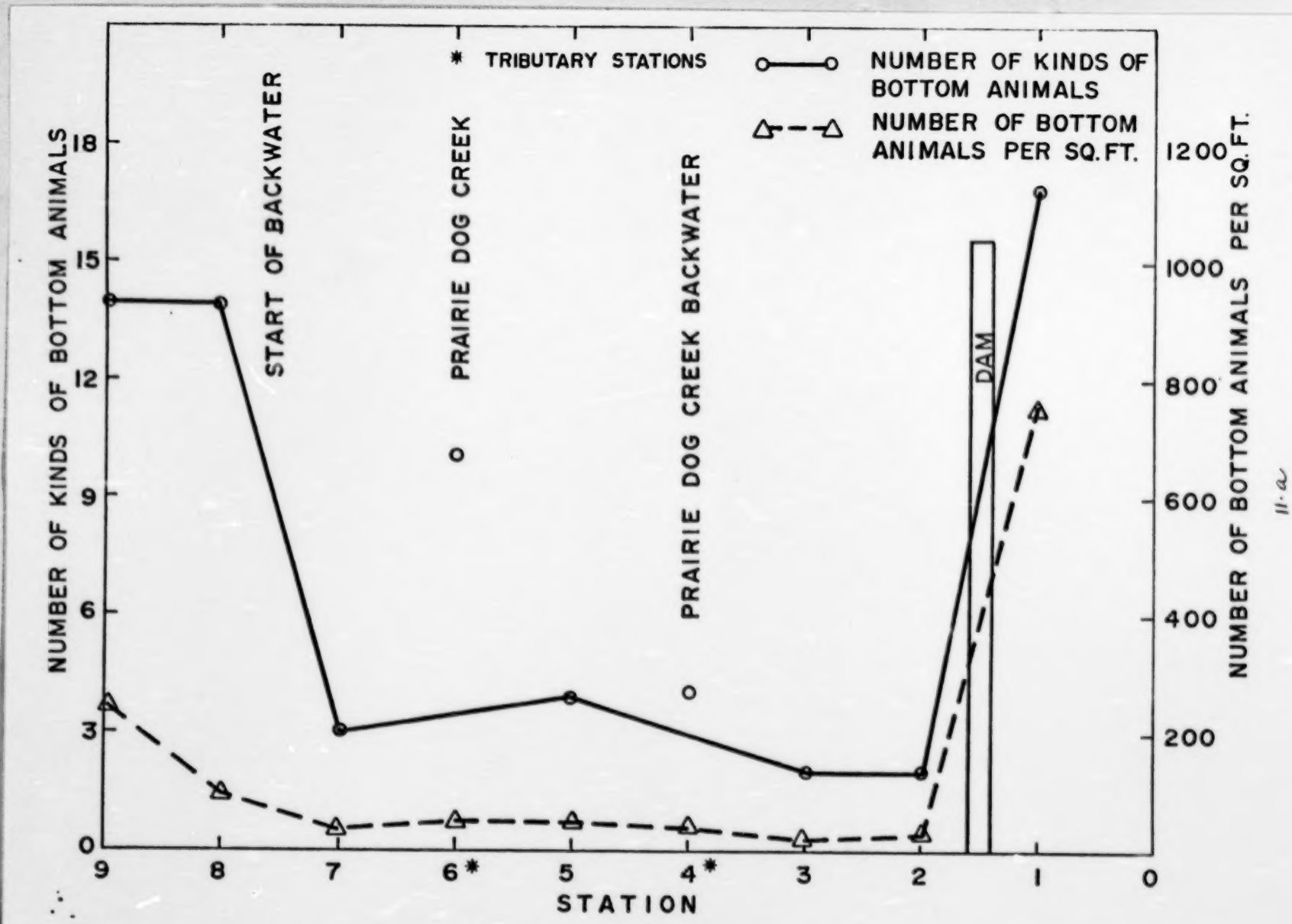

Fig. 5 Number of Kinds and Number per square foot of Bottom Animals, Harlan County Reservoir, Nebraska, 1969

11-a

Many of these organisms were pollution sensitive mayflies and caddisflies. The population downstream from the reservoir, with its greater diversity and number, indicated that the water quality was higher downstream from the reservoir than upstream. The large population of bottom animals probably resulted from the development of an attached algal community that provided food for the benthic animal community.

Table 1. Harlan County Reservoir--Nebraska

Bottom Animal Data, August 1969

	HC-1	Rt. HC-2	Ct. HC-2	LF. HC-2	Ct HC-3	Rt. HC-5	Ct. HC-5	LF. HC-5	LF. HC-7	Rt. HC-7	HC-8	HC-9	Prairie Dog Cr. HC-4	Prairie Dog Cr. Lacwater HC-6
Mayflies														
Isonychia	30	-	-	-	-	-	-	-	-	-	-	Q	-	-
Baetis	65	-	-	-	-	-	-	-	-	-	Q	7	-	Q
Heptagenia	29	-	-	-	-	-	-	-	-	-	Q	Q	-	-
Trichorythodes	46	-	-	-	-	-	-	-	-	-	-	3	-	-
Stenonema	-	-	-	-	-	-	-	-	-	-	Q	91	-	Q
Hexagenia	-	-	-	-	-	-	-	-	-	-	Q	-	-	-
Caenis	-	-	-	-	-	-	-	-	-	-	Q	90	-	-
Caddisflies														
Chemato-psyche	120	-	-	-	-	-	-	-	-	-	Q	Q	-	Q
Hydropsyche	26	-	-	-	-	-	-	-	-	-	Q	1	-	-
Agreylea	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Midges														
Cryptochironomus	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum	69	-	-	-	-	-	-	-	2	-	Q	5	-	Q
Spaniotoma	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelopia	-	2	-	2	2	3	2	48	-	2	-	-	8	-
Pentaneura	-	-	-	-	-	-	-	-	-	-	Q	-	-	Q
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Stoneflies														
Pteronarcys	-	-	-	-	-	-	-	-	-	-	Q	Q	-	-
Acroneuria	-	-	-	-	-	-	-	-	-	-	Q	-	-	-
Blackflies														
Prosimulium	168	-	-	-	-	-	-	-	-	-	-	Q	-	Q
Simulium	80	-	-	-	-	-	-	-	-	-	-	-	-	-
Beetles														
Laccobius	Q	-	-	-	-	-	-	-	-	-	-	-	-	
Damselflies														
Argia	-	-	-	-	-	-	-	-	-	-	-	3	-	
Dragonflies														
Gomphus	-	-	-	-	-	-	-	-	-	-	Q	Q	-	-
Phantom midge														
Chaoborus	-	-	-	-	-	2	2	-	3	-	-	-	2	-
Snail														
Physa	Q	-	-	-	-	-	-	-	-	-	Q	-	-	-
Leech	Q	-	-	-	-	-	-	-	-	-	-	-	-	Q
Planaria	Q	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludgeworms	25	12	8	27	12	20	24	78	37	17	97	42	17	48
Bloodworms	3	-	-	8	-	2	5	17	10	-	-	-	12	-
Total No. Kinds	17	3	1	5	2	4	4	3	4	2	14	14	4	10
Total No./Sq.Ft.	760	17	8	37	14	27	33	143	52	19	97	242	39	48

Q = Collected in qualitative sample, not counted in total.

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Table 2

Harlan County Reservoir - Nebraska

Algal and Chemical Data

August 1969

	HC-1	HC-2 LF 0'	HC-2 LF 5'	PM HC-2 CT 0'	AM HC-2 CT 5'	HC-2 HT 0'	HC-3 CT 0'	HC-3 CT 10'	HC-3 CT 20'	HC-3 CT 30'	HC-5 CT 0'	HC-5 LF 0	HC-7 LF 0'	HC-7 LF 5'	HC-7 HT 0'	HC-7 HT 5'	HC-8	HC-9	HC-4 0'	HC-4 CT 5'	HC-6 0'
Greens No/ml	106	3394	530	636	583	689	689	477	0	318	14734	1007	742	689	848	1379	18939	18513	583	901	1644
ppm	0.6	4.6	1.4	1.4	1.0	1.4	1.4	0.9	-	0.7	21.2	1.9	1.7	1.5	1.7	2.8	23.8	22.3	1.1	2.7	3.4
Flagellates No/ml	265	424	530	414	53	212	901	902	265	106	424	1114	2493	583	1857	2227	2758	3660	902	954	1590
ppm	0.5	0.6	0.7	0.7	0.1	0.4	1.3	1.7	0.6	0.2	0.8	2.1	17.1	21.9	12.8	4.3	5.3	45.5	1.7	2.2	3.1
Bluegreens No/ml	318	3394	901	1166	848	1326	1273	689	318	424	1855	1113	265	2546	318	424	2175	5890	1592	1273	159
ppm	0.1	0.8	0.4	0.4	0.3	0.4	0.4	0.2	0.2	0.1	0.6	0.5	0.1	0.2	0.1	0.2	0.8	1.5	0.7	0.6	-
Diatoms No/ml	53	53	0	0	53	0	0	0	0	53	53	106	0	53	159	0	848	1538	0	53	265
ppm	1.2	0.1	-	-	0.1	-	-	-	-	0.1	0.1	0.1	-	0.1	0.2	-	0.4	1.2	-	0.1	0.3
Total No/ml	742	6520	1961	2288	1537	2226	2865	2068	584	902	17066	3334	3501	3871	3236	4032	24720	29601	3077	3183	3658
Vol. ppm	1.2	6.1	2.5	2.5	1.5	2.2	3.1	2.8	0.8	1.1	22.7	4.6	18.9	23.7	14.8	7.3	30.3	70.5	3.5	5.6	6.8
Organic N mg/l	.8	1.2	.8	.8	.6	1.2	.8	.6	.5	.6	1.4	1.0	1.9	1.5	1.7	1.8	1.5	1.5	1.4	.9	2.1
NO_3-N mg/l	.3	.2	.1	.1	.1	< .1	< .1	< .1	.1	.1	< .1	< .1	< .1	< .1	< .1	1.5	< .1	< .1	< .1	< .1	.8
NH_3-N mg/l	.13	.27	.14	.14	.18	.07	.21	.09	.05	.06	.41	.14	.40	.07	.32	.10	.03	.10	.10	.40	.33
Total Inorganic Nitrogen	.4	.5	.2	.2	.2	< .2	< .3	< .2	.2	.2	< .5	< .2	.5	< .2	< .4	2.6	< .1	< .2	< .2	< .5	1.1
Total P mg/l	.19	.10	.10	.09	.09	.10	.10	.10	.10	.10	.13	.10	.23	.32	.36	.41	.40	.40	.13	.11	.61
Soluble P mg/l	.05	.05	.05	.04	.04	.08	.06	.05	.03	.05	.04	.04	.05	.10	.04	.07	.09	.17	.06	.06	.25